

Southern Fine Particulate Monitoring Project

Fifth Quarterly Progress Report

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Abstract

This quarterly report presents results and analysis of continuous onsite ambient fine particulate data at the North Birmingham sampling site during the October - December, 2001 study period. The continuous data include PM_{2.5} mass concentrations measured by TEOM, particle sulfate using the R&P 8400S monitor, particle size distributions measured by SMPS and APS monitors, and PM_{2.5} light scattering extinction coefficient as measured by nephelometer. The persistent daily trends described in the previous quarterly report are seen in the fall particulate data, superimposed on the seasonal trend toward lower concentrations in the cooler months. Some instrumental issues were noted with the APS and the sulfate monitoring instruments, as described in the main report.

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Introduction

This is the fifth quarterly progress report of the “Southern Fine Particulate Monitoring Project”, funded by the U.S. Department of Energy’s National Energy Technology Laboratory under DOE Cooperative Agreement No. DE-FC26-00NT40770 to Southern Research Institute (SRI). In this two year project SRI will conduct detailed studies of ambient fine particulate matter in the Birmingham, AL metropolitan area. Project objectives include:

- \$ Augment existing measurements of primary and secondary aerosols at an established urban southeastern monitoring site
- \$ Make a detailed database of near-continuous measurements of the time variation of fine particulate mass, composition, and key properties (including particle size distribution)
- \$ Apply the measurements to source attribution, time/transport properties of fine PM, and implications for management strategies for PM_{2.5}
- \$ Validate and compare key measurement methods used in this study for applicability within other PM_{2.5} research by DOE-FE, EPA, NARSTO, and others.

Summary of Technical Progress

Progress and Plans

During the fifth project quarter, continuous onsite ambient data were collected and monitored. Details include:

- \$ Continued field testing for particulate sulfate monitor of Harvard design
- \$ Continued monitoring with TEOM, particle sizing instruments, R&P 8400 Sulfate monitor, Radiance M904 Nephelometer, and 43CTL Sulfur Dioxide analyzer
- \$ Poster presented at American Association for Aerosol Research conference in Portland, OR.

Plans for next quarter include the following:

- \$ January measurement intensive with Eastern Supersite Program
- \$ Field study comparisons for ambient and dried measurements using TEOM, Nephelometer, and particle size package
- \$ Onsite comparative measurements with particulate sulfate monitor of Harvard design, R&P 8400S and SEARCH Particulate Composition Matter (PCM) results
- \$ Prepare July data in general format for modeling study
- \$ Upgrade the TSI APS 3320 to an APS 3321
- \$ Continue onsite monitoring with continuous monitoring instruments
- \$ Continue analysis of initial continuous particulate data

Problems and Assessment for Future Progress

Inspection of the APS data suggested several periods of suspect operation where partial nozzle

clogging may have reduced particle collection efficiency and/or disturbed the aerodynamic sizing response. The TSI APS 3320 was originally scheduled to be upgraded to an APS 3321 in December 2001, which would allow redeployment before the ESP02 intensive in January. Due to engineering difficulties at TSI, our instrument will not be sent for improvements until January or February 2002. Other instrument issues were noted with the 8400S sulfate monitor and the instrument based on the HSPH model. Some data loss occurred with each device.

Experimental

Several instrumental issues arose and were addressed during the quarter. Through daily routine inspections of SRI's instrumentation at the North Birmingham air monitoring station, it was discovered that the sheath pump voltage on the APS had gone to zero on 10/30/01. Sheath air was not being pulled through the instrument, which caused the sample flow not to be transported and dispersed through the detection area as designed. The instrument was removed from the North Birmingham site and returned to SRI for routine cleaning and testing. The inner and outer nozzles of the APS were removed, thoroughly inspected and cleaned. It appeared particulate collected over time in the inner nozzle causing the sheath pump control voltage to decrease over time and eventually shut down. After the cleaning, the instrument's performance was verified by creating an aerosol with 3 different polystyrene latex standards within the instrument's detection limit. All three standards fell within the proper size channels of the APS. The instrument was redeployed to the air monitoring station 11/2/01. Inspection of the APS data suggested several periods of suspect operation where partial nozzle clogging may have reduced particle collection efficiency and/or disturbed the aerodynamic sizing response. It was also noted that our instrument was subject to reported limitations of the APS 3320; that is, reduced counting efficiency at higher count levels and artifact counts in the largest size bins (especially over 5-10 μm). Both effects can distort mass concentrations reconstructed from APS data, so we made arrangements with TSI to upgrade the APS 3320 to an APS 3321, which was a redesign to overcome these limitations. The unit was originally scheduled to be in December 2001, but had to be rescheduled to January or February 2002.

As reported previously, we assembled a prototype sulfate monitor based on the design of George Allen from the Harvard School of Public Health in the SRI laboratory. Laboratory testing and comparisons had been completed in preparation for field deployment and testing. After deployment in the shelter, we noticed temperature sensitivity of the instrument, as well as excessive fluctuations in the SO₂ signal that coincide with the heating and air conditioning cycles of the shelter heat pump. We have attempted several approaches to mitigate the effects of temperature changes in the shelter, but are not satisfied with the current status of the instrument.

As described previously, the R&P 8400S sulfate analyzer had shown a tendency to erratic variation in analyzer UV lamp intensity from day to day in addition to the overall decrease typical for these flashlamps. Since the analyzer's lamp intensity compensation did not completely correct for this variability, fluctuations in signal intensity were evident in the daily analyzer audit data. After consultation with R&P, the vendor agreed to send a replacement lamp that was installed in the hope of greater stability in the future. On November 8, the new lamp was installed, a "Factory Cal" and zero/span calibration were performed on the analyzer. After installation, the lamp intensity gradually dropped to about 60 percent of the original value, as

expected during break-in. The lamp intensity was still subject to "spikes" especially after power interruptions, but not of the magnitude of the erratic swings seen with the previous lamp. Since the instrument's internal correction factor still did not completely correct for this variability, a postprocessing correction factor based on the audit data and lamp intensity will still be necessary. We are continuing to explore with R&P possible improvements on this methodology.

Results and Discussion

Hourly averages of the continuous particulate measurements are presented in Figures 1 - 6. The data are plotted together for a meaningful comparison between instruments and data sets. The figures contain the PM_{2.5} mass concentrations measured by the TEOM, 8400S sulfate monitor and integrated size fractions measured by the particle sizing devices. Included are total (submicron) mass concentration as derived from the SMPS measurements, and integrated mass concentrations in the 1 - 2.5 and 2.5 - 10 µm size ranges from the APS measurement data. The PM_{2.5} light scattering extinction coefficient as measured by the M903 nephelometer is plotted on the second Y-axis. In addition, hourly average PM₁₀ concentration data were obtained from the Jefferson County Health Department as measured by the county TEOM monitor at the site.

Figures 1 - 3 display the variables associated with the measurements in the fine particulate region. The data sets displayed are the PM_{2.5} TEOM, SMPS total concentration, the 1 - 2.5 µm APS fraction, the 8400S sulfate monitor and the M903 nephelometer. The figures present the same five variables over the months October, November, and December, respectively. Figures 4 - 6 represent the variables associated with particulate measurements in the coarse size region, including the PM₁₀ TEOM and the 2.5 - 10 µm APS fraction, as well as the PM_{2.5} TEOM concentrations for reference.

As described in previous quarterly reports, some persistent daily trends are seen in the particulate data, superimposed on a seasonal trend toward higher concentrations in warmer months. To depict PM_{2.5} trends during the day, the PM_{2.5} TEOM mass concentration hourly averages were averaged with the corresponding hour for each day throughout the month. Figure 7 displays this comparison for each month our data have been collected at the North Birmingham site. Overnight steady high levels followed by rush hour peaks are seen to some extent during each month of data collection. After the morning peak, average concentrations dropped to a lower level during daylight hours, followed by a steady rise from late afternoon to midnight. The fall months continue the trend toward lower daylight hour concentrations started in September. The morning rush hour peak is shifted to later times in the latest quarter, roughly corresponding to the time pattern of both sunrise and traffic flow (note that the time axis is on Central Standard Time for all months, but rush hour patterns tend to follow daylight savings time patterns). In December all measures of particle concentration are lower than previous months.

Conclusions

Data collected in this quarter continuation of the seasonal trends from previous quarters. The next quarterly report will reflect a full year of data for most devices used.

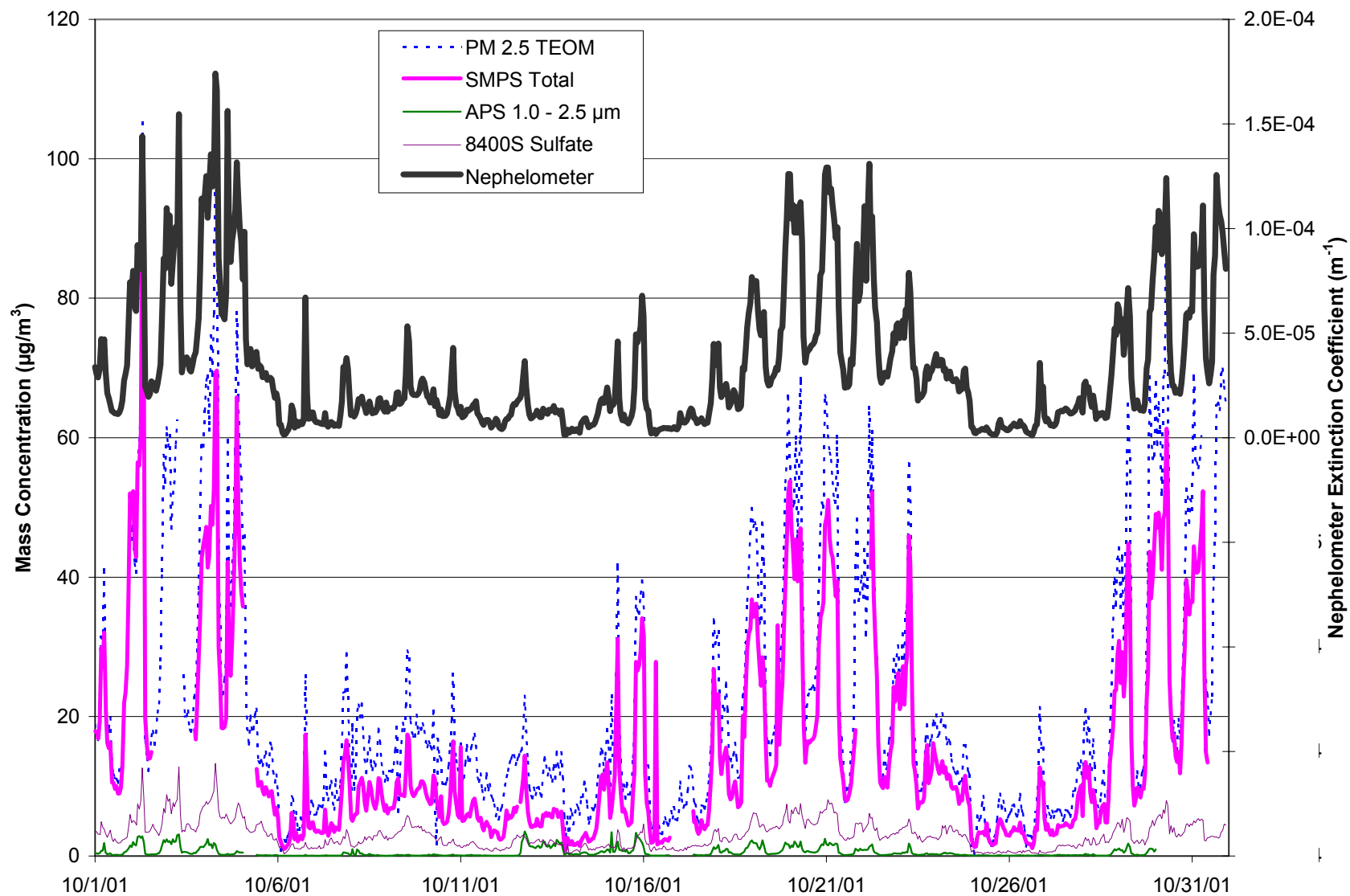


Figure 1. Hourly averaged fine particle data from the North Birmingham site during the period of October 1 – October 31, 2001.

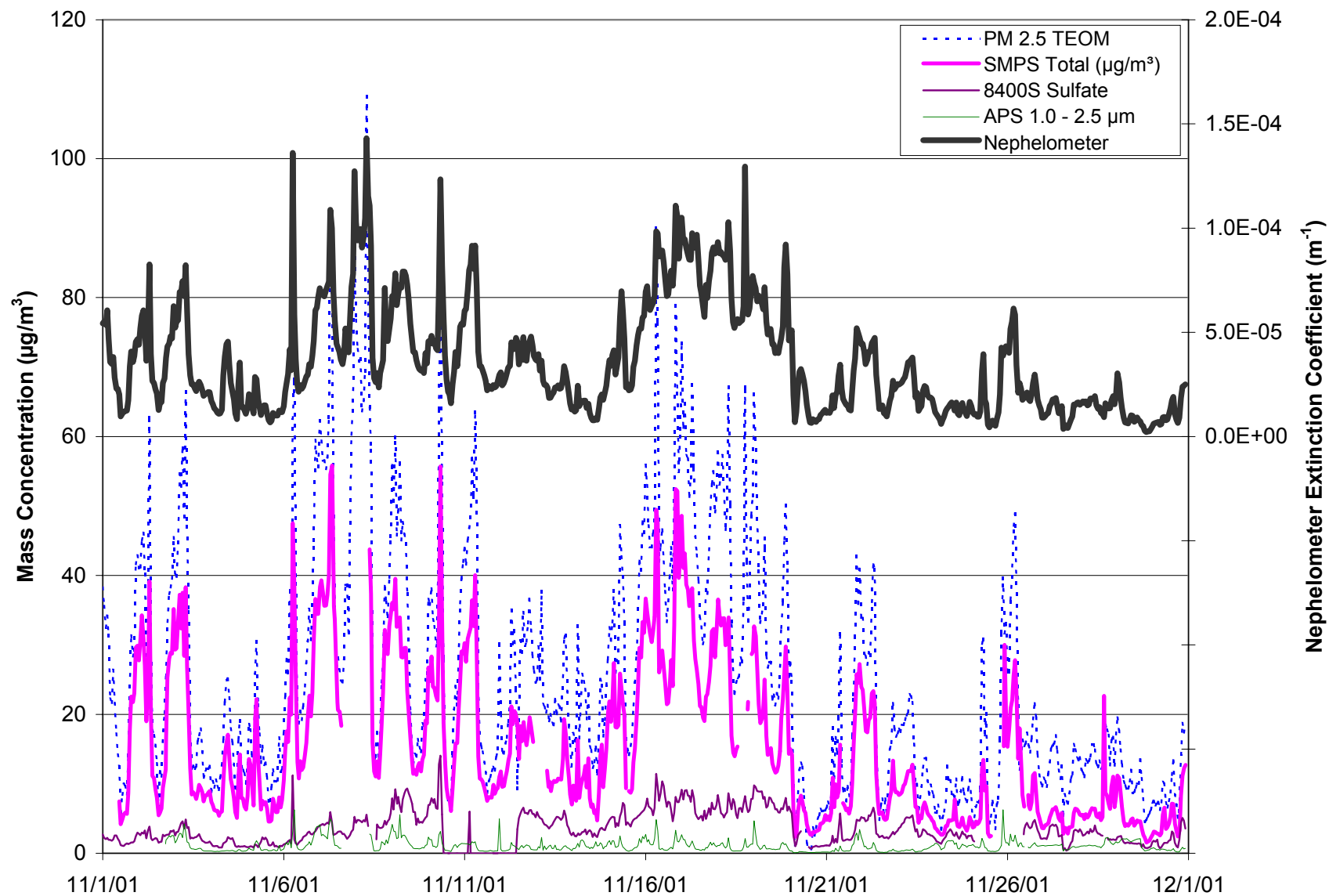


Figure 2. Hourly averaged fine particle data from the North Birmingham site during the period of November 1 – November 30, 2001.

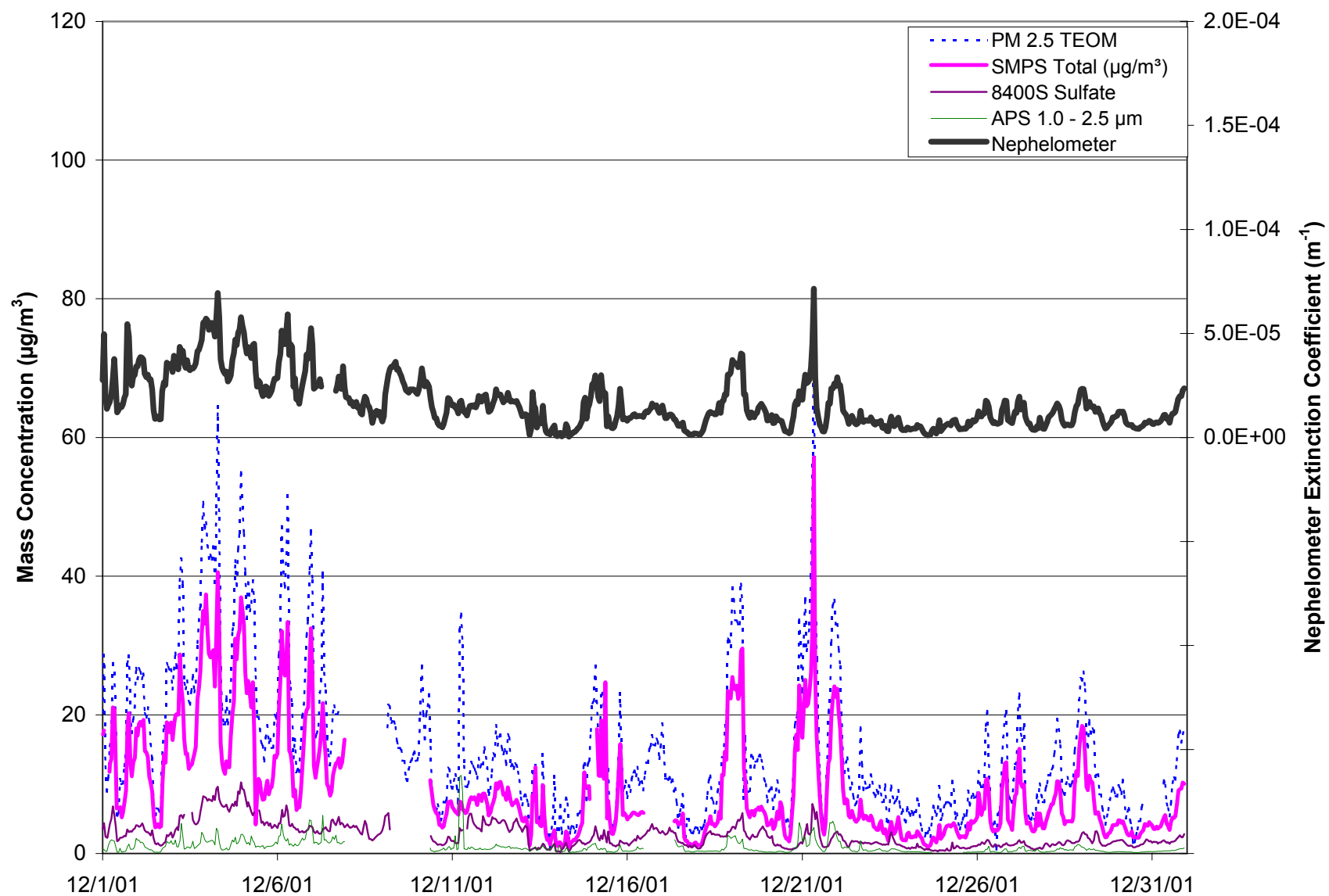


Figure 3. Hourly averaged fine particle data from the North Birmingham site during the period of December 1 – December 31, 2001.

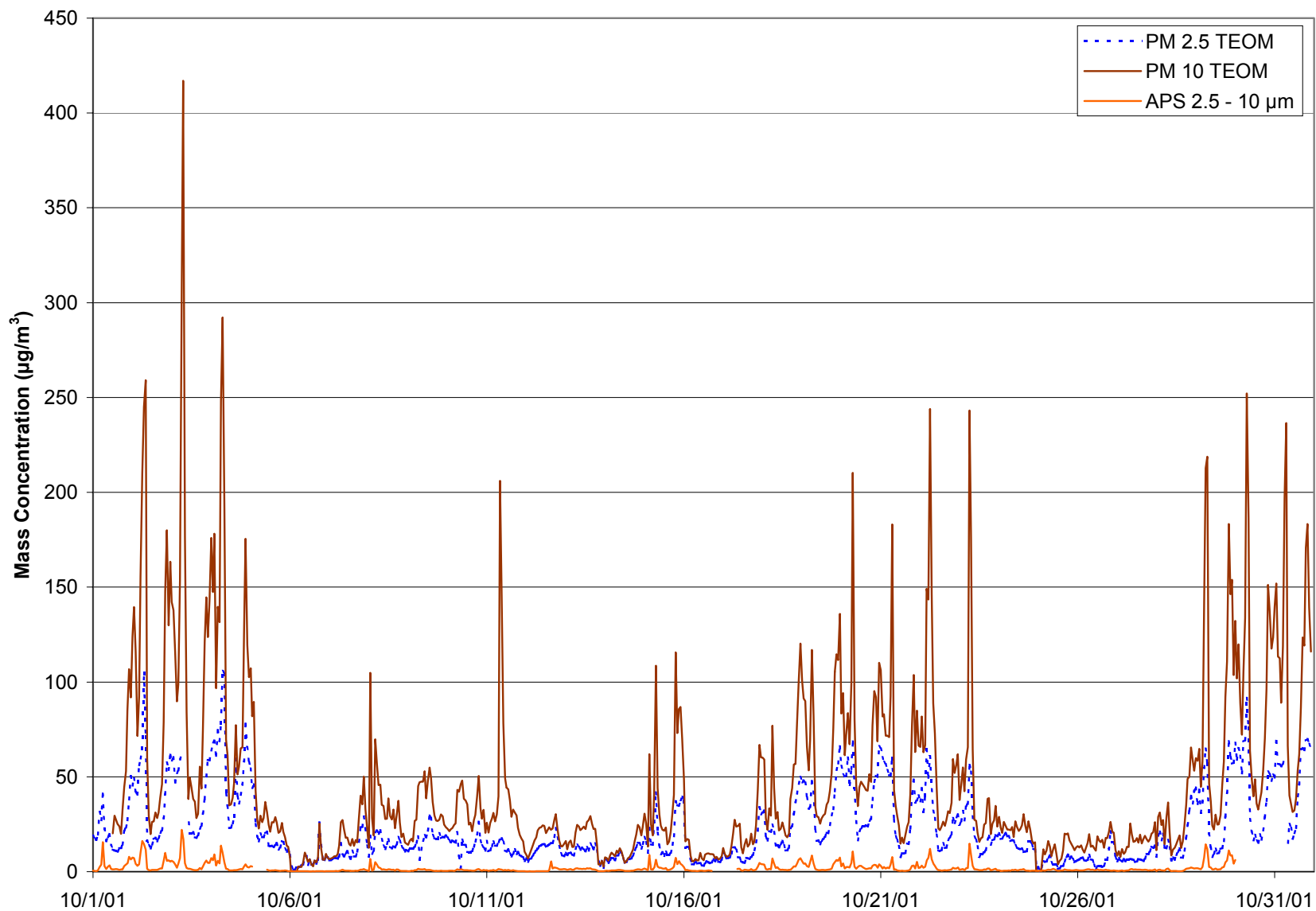


Figure 4. Hourly averaged coarse particle data from the North Birmingham site during the period of October 1 – October 31, 2001. Also included are PM₁₀ concentrations reported by Jefferson County

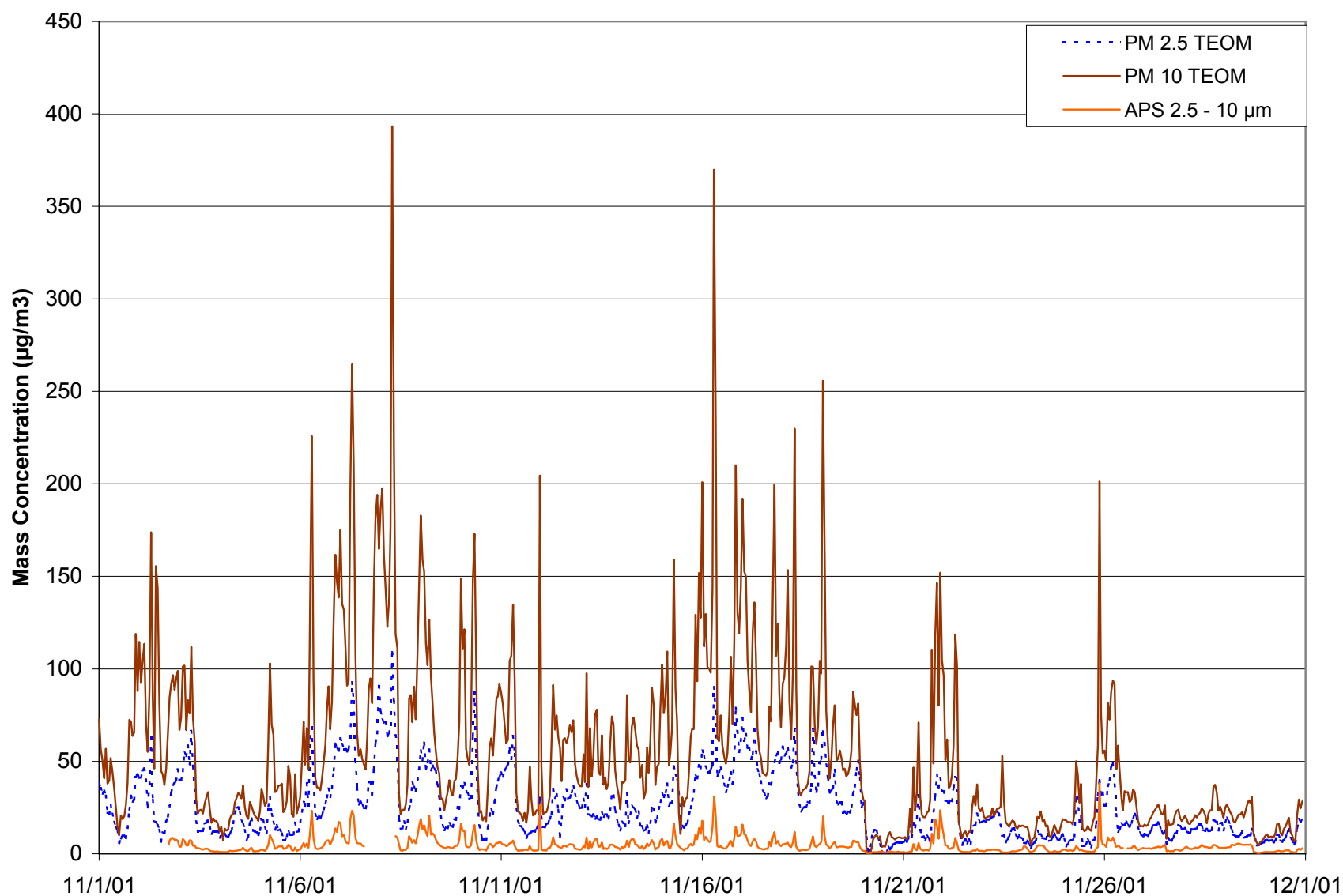


Figure 5. Hourly averaged coarse particle data from the North Birmingham site during the period of November 1 – November 30, 2001. Also included are PM₁₀ concentrations reported by Jefferson County.

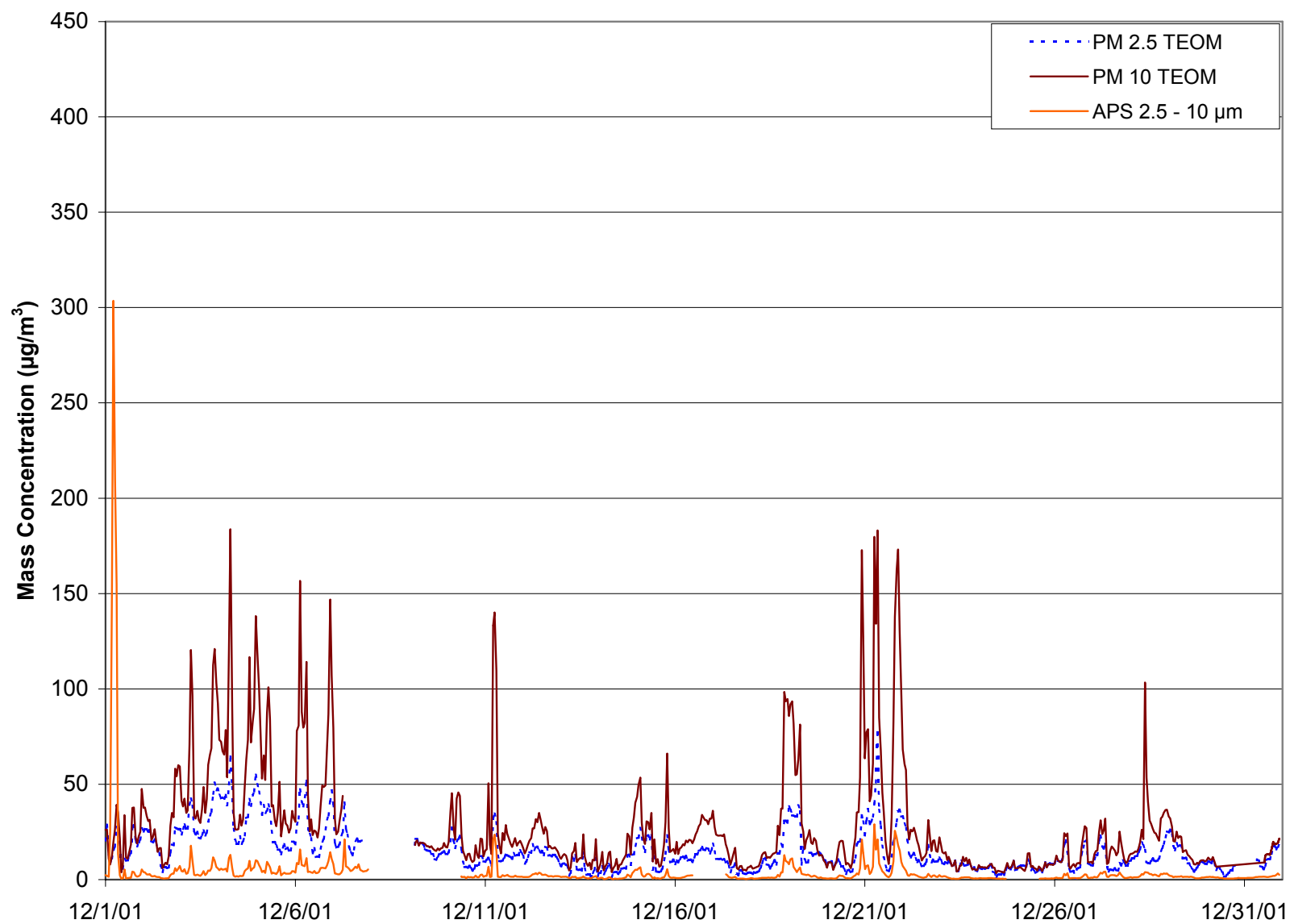


Figure 6. Hourly averaged coarse particle data from the North Birmingham site during the period of December 1 – December 31, 2001. Also included are PM₁₀ concentrations reported by Jefferson County.

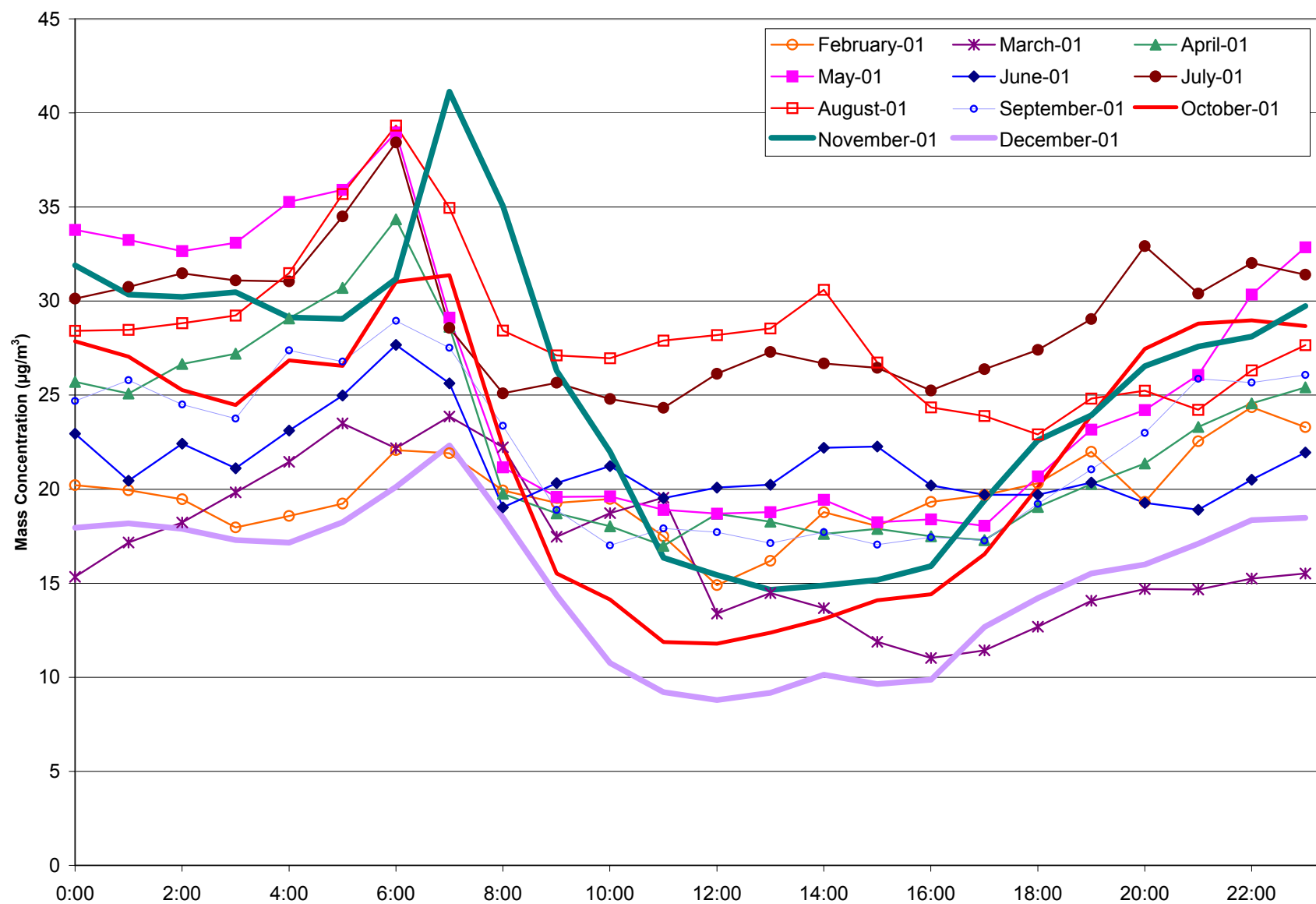


Figure 7. PM_{2.5} TEOM hourly time of day averages for each month of data collected at the North Birmingham site.